Attorney Docket No. 095309.57761US

METHOD FOR INTERNAL HIGH-PRESSURE DEFORMATION OF A BLANK

BACKGROUND AND SUMMARY OF THE INVENTION

[0001] This invention relates to a method for operating an apparatus for hydroforming a blank.

[0002] Hydroforming is becoming increasingly important in the automotive industry in order to allow the production of body components. First of all, undeformed blanks, for example tubes, are inserted into the receiving space of a die. The geometry of a receiving space corresponds to the desired external geometry of the finished component. The blank is acted on by high-pressure fluid so that the walls of the blank are plastically deformed and come to bear against the walls of the receiving space. It is in this way possible to economically produce high-strength, complex components.

[0003] To assist the deformation process and to minimize friction which occurs between the wall of the receiving space and the outer skin of the blank, it is known from European document EP 0 771 598 A1 to supply the receiving space with lubricant. The lubricant has the effect of allowing the outer skin of the blank to slide along the wall of the receiving space. It is in this way possible to avoid undesirable distortion.

[0004] German document DE 199 44 722 A1 discloses a method for operating a hydroforming die, in which during the deformation of a hollow body which is present in the die, lubricant is delivered into the forming zone of the die via feedlines running inside the forming die and is if appropriate removed again.

[0005] German document DE 102 02 201 A1 discloses a method in which, likewise during the deformation of a hollow body which is present in the forming die, lubricant is delivered into the forming zone of the die via feedlines running inside the forming die and is if appropriate removed again. In this method, however, the feedlines for supplying the lubricant and those used to discharge it are different.

[0006] British document GB 21 26 510 A discloses a production process and an apparatus in which, during the deformation of a hollow profiled section in a hydroforming die, excess pressurized fluid is removed via passages running inside the forming die. To facilitate the deformation, the hollow profiled section is lubricated with pressurized fluid on the outer side.

[0007] According to German document DE 102 02 201 A1, the principle which is known from European publication EP 0 771 598 A1 is further developed in such a way that a flow of lubricant is generated in the receiving space of the die, so that the deformation process can be assisted even more effectively.

[0008] One problem with the hydroforming apparatuses which are known from the prior art is that, following the actual deformation operation, residual fluid collects in the receiving space. This residual fluid may contain high-pressure fluid, lubricants and/or inclusions of air. After the blank has been removed from the die, the residual fluid remains in the receiving space and may have an adverse effect on a subsequent deformation process. On the one hand, the residual fluid enclosed in the receiving space is substantially not compressible, with the ensuing risk that a blank that is to be deformed cannot adopt the geometry predetermined by the wall of the receiving space during the deformation process and remains undeformed in a region in which residual fluid is present in the receiving space. A second problem is that a reliable supply of lubricant is not ensured in those regions of the receiving space in which the residual fluid has collected.

[0009] Working on this basis, the object of the present invention is to improve a method of the type referred to above in such a manner that a reproducibly good process quality is ensured.

[0010] According to the invention, this object is achieved by the features claimed.

[0011] According to the invention, prior to the deformation of a blank, residual fluid which is present in the receiving space of die is removed from the

receiving space through a passage. Lubricant is then fed to the receiving space, and the interior of the blank is supplied with high-pressure fluid. This removal of residual fluid can be assisted by the application of subatmospheric pressure or superatmospheric pressure to the passage.

[0012] Alternatively, prior to the deformation of a blank, residual fluid which is present in the receiving space is removed from the receiving space through the passage by lubricant being fed to the receiving space to displace the residual fluid. High-pressure fluid is thereafter supplied to the interior of the blank.

[0013] In the abovementioned methods, it may be advantageous to use a low-viscosity lubricant, since, compared to high-viscosity lubricants, a low-viscosity lubricant is easier to remove from the receiving space of a die.

[0014] As has already been explained above, the residual fluid substantially comprises high-pressure fluid but may also include dirt particles, lubricant residues and/or inclusions of air. The at least one passage ensures that the receiving space can be drained or vented before a deformation process begins, so that a subsequent deformation process is not affected or disrupted by the presence of residual fluid in the receiving space.

[0015] To assist with the removal of the residual fluid, it is possible for there to be suction means which can be used to apply a subatmospheric pressure to the passage. By way of example, it is possible to provide a suction pump which is connected to the at least one passage, so that high-pressure fluid, lubricant residues and/or air can be sucked out of the receiving space.

[0016] In addition or as an option, it is also possible for there to be a pressure supply. This pressure supply can be used to apply superatmospheric pressure to the passage. Therefore, a superatmospheric pressure can be built up in the region where the passage opens out in the receiving space, with the result that residual fluid which is present in the receiving space is forced out of the receiving space through the passage.

[0017] The die may have lines which open out in the receiving space for supplying and/or removing lubricant. These lines may each be suitable for one direction of transport or may be suitable for both directions of transport, i.e. for both supplying and removing lubricant.

[0018] It is particularly advantageous if the passage through which residual fluid located in the receiving space can be removed from the receiving space is also suitable for supplying and/or removing lubricant. This allows the die to be of particularly simple configuration, since only at least one passage need be present compared to the use of separate passages and lines.

[0019] Further advantageous configurations and details of the invention are to be found in the following description, in which the invention is explained and described in more detail on the basis of the exemplary embodiments illustrated in the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] Figure 1 shows a sectional side view of a first hydroforming apparatus during the removal of residual fluid by suction;

[0021] Figure 2 shows the apparatus of Figure 1 during the supply of lubricant; and

[0022] Figure 3 shows a sectional side view of a second hydroforming apparatus during the removal of residual fluid by displacement with lubricant.

DETAILED DESCRIPTION OF THE INVENTION

[0023] The apparatus, which is denoted overall by reference numeral 2 in Figure 1, has an upper die half 4 and a lower die half 6. The die halves 4 and 6 delimit a receiving space 8, the wall 10 of which corresponds to the external geometry of a shaped part which is to be produced.

[0024] An as yet undeformed, tubular blank 12 has been inserted into the receiving space 8, the outer skin 14 of which blank 12 comes to bear against the wall 10 of the receiving space 8 during the deformation process. The blank 12 may be laterally sealed with the aid of axial cylinders 16 and 18, the axial cylinder 18 having a line 20 for a high-pressure fluid supply (not shown). High-pressure fluid can be introduced into the cavity of the blank 12 through the line 20, so that the blank 12 can be deformed.

[0025] The lower die half 6 has three passages 22, 24 and 26 opening out in the receiving space 10. These passages are connected to a manifold 28. Accordingly, the upper die half 4 has passages 30, 32 and 34, which likewise open out in the receiving space 8 of the apparatus 2 and lead to a manifold 36. The manifold 36 of the upper die half 4 and the manifold 28 of the lower die half 6 lead to a common main passage 38.

[0026] The main passage 38 is connected to suction means (not shown), for example a vacuum pump. By applying a vacuum, residual fluid 40 which is present in the receiving space 10 can be removed from the receiving space 8 in accordance with the directions of flow indicated by the arrows in the passages 22 to 38. The residual fluid 40 may comprise high-pressure fluid, residues of lubricants and/or inclusions of air. The removal of the residual fluid 40 allows the receiving space 8 to be drained and vented, so that a subsequent deformation

process carried out on the blank 12 is not disrupted by the presence of residual fluid in the receiving space 8.

[0027] Figure 2 illustrates the apparatus 2 of Figure 1 in a subsequent process step. The axial cylinders 16 and 18 have been displaced in the direction of the receiving space 8 compared to the position illustrated in Figure 1, so that the axial cylinders 16 and 18 bear in a sealing manner against the blank 12. A high-pressure fluid can now be supplied through the line 20. Simultaneously with or prior to high-pressure fluid being supplied to the line 20, the passages 22 to 38 can be used to feed a lubricant, denoted by 42, to the receiving space 8. For this purpose, the main passage 38 is coupled to a lubricant supply. The lubricant 42 passes into the receiving space 8 in the region where the passages 22 to 26 and 30 to 34 open out. As a result, during the subsequent deformation process carried out on the blank 12, it is ensured that the outer skin 14 of the blank 12 can bear against the wall 10 of the receiving space 8 without any friction losses.

[0028] Figure 3 illustrates an apparatus 2' which is similar to the apparatus 2 shown in Figures 1 and 2. The reference numerals shown in Figure 3 are identical where they denote the same components as in the apparatus 2 shown in Figures 1 and 2. The lower die half 6 of the apparatus 2' has passages 22, 24 and 26 which lead to a manifold 28'. Residual fluid 40 which is present in the receiving space 8 of the apparatus 2' can be removed through the manifold 28'. The upper die half 6 of the apparatus 2' has passages 30, 32

and 34 which lead to a manifold 36'. Lubricant 42 can be fed to the receiving space 8 of the apparatus 2' through the manifold 36'. Unlike in the apparatus 2 shown in Figures 1 and 2, the manifolds 28' and 36' of the apparatus 2' shown in Figure 3 are not in communication with one another.

[0029] With the embodiment illustrated in Figure 3, it is possible for residual fluid 40 which is present in the receiving space 8 of the apparatus 2' to be removed from the receiving space 8 by lubricant 42 being supplied through the manifold 36', which lubricant passes via the passages 30 to 34 into the receiving space 8, where it displaces residual fluid 40 which is present in the receiving space 8 and can be discharged via the passages 22 to 26 and ultimately via the manifold 28.'